

Application of Information Technology ■

The Asthma Kiosk: A Patient-centered Technology for Collaborative Decision Support in the Emergency Department

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Abstract The authors report on the development and evaluation of a novel patient-centered technology that promotes capture of critical information necessary to drive guideline-based care for pediatric asthma. The design of this application, the asthma kiosk, addresses five critical issues for patient-centered technology that promotes guideline-based care: (1) a front-end mechanism for patient-driven data capture, (2) neutrality regarding patients' medical expertise and technical backgrounds, (3) granular capture of medication data directly from the patient, (4) formal algorithms linking patient-level semantics and asthma guidelines, and (5) output to both patients and clinical providers regarding best practice. The formative evaluation of the asthma kiosk demonstrates its ability to capture patient-specific data during real-time care in the emergency department (ED) with a mean completion time of 11 minutes. The asthma kiosk successfully links parents' data to guideline recommendations and identifies data critical to health improvements for asthmatic children that otherwise remains undocumented during ED-based care.

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Correct clinical actions require that a provider collect and understand relevant history derived from a comprehensive patient interview. Lack of information precludes the ability to initiate appropriate actions.¹ The busy emergency department (ED) setting imposes multiple barriers to adequate communication and sharing of data. We present a novel application, the asthma kiosk, that provides a patient-driven, electronic solution to capture critical historical data needed for collaborative patient-provider interactions and guideline-based clinical care.

Background

The ED is a unique and important health care environment, providing access to all patients who require care and a gateway to hospital-based inpatient services.² Many clinical decisions regarding care are made at the bedside in the context of

uncertainty and incomplete data. Information systems can provide electronic solutions to address this uncertainty and support guideline-based care but require sufficient and accurate data.³ Lack of prior knowledge of a patient's history limits automated discovery of data that would populate algorithms for guideline adherence.⁴

Pediatric asthma serves as a model disease in which to engineer an electronic, patient-centered approach to supporting best practice in the ED. The data necessary to populate the algorithms that govern best practice are largely historical (chronic symptoms, a detailed account of current medications, current behaviors, triggers of disease, and management strategies).⁵ These data elements are within the sphere of parents' knowledge, and represent routine territory for verbal interviews between a parent and a nurse or doctor. In pediatrics, parents serve as proxy reporters for their children, and are an integral part of the "patient unit."

Parents of pediatric patients and older patients who can speak for themselves are an underutilized resource for information that drives the practice of evidence-based care. Wagner's paradigm for the delivery of idealized care provides a central role for an "active and informed" patient.⁶ However, informatics-based systems designed to promote guideline adherence often rely on existing administrative and historical data to the exclusion of patients participating in data discovery.^{7,8} The ATHENA system uses pre-existing data in medical records systems and thus relies on populated data fields and longitudinal records to drive decision support.⁸ Such a system could not be adopted in the ED setting, where prior records and pre-existing data are not universally available, accurate, or readable.⁴ Other informatics-based approaches focus on the clinical provider (nurse, nurse practitioner, or physician) and directly support providers' documentation without carving out a role for the patient in capture and review of medical data.⁹⁻¹¹

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We designed a patient-centered interface to allow parents of children with asthma to be active providers of knowledge and promoters of quality of care in the ED. We completed a formative evaluation of the asthma kiosk and report on its system design and field testing of the application.

Design Objectives

1. Design a Front-end Interface for Patient-driven Data Capture that Fits Physical and Logistical Challenges of the ED Setting

Background noise, the stress arising from patients' illnesses, and the fast-paced, crowded environment of the ED pervade the care experience in this setting and adversely affect communication.¹² Patients in the ED experience time-variable patterns of movement wherein they may sit in one area for an extended time and/or be transferred between multiple rooms over time. The amount of time that a given patient can spend on data entry early in the process of ED care (when data capture has its largest theoretical benefit) is variable but finite. Parents who are the proxy reporters for their child may experience physical constraints on the data entry process, either from a need to hold a child or to maintain a comfortable posture.

The interface and architectural characteristics required to meet these demands include: (1) mobility of the hardware, (2) modular approach to data entry, (3) visual simplicity, and (4) physical and cognitive ease of use.

2. Implement an Interface That Is Neutral to a Patient's Technology-based Experience or Medical Expertise

Technology implemented in a health care setting should not introduce a "digital divide" through its reliance on physical or mental skills not common to all, such as use of keyboard or sophisticated medical jargon. Variable literacy skills in the U.S. population make a text-only approach to collection and dissemination of health information untenable.¹³ Prior exposure to and/or use of technology such as e-mail varies by income level and introduces an a priori concern that the urban poor may be at a disadvantage in using technology to communicate health information.¹⁴

The interface and architectural requirements needed to meet these challenges include: (1) data entry that is independent of keyboard use, (2) a multimedia approach to collection and dissemination of patient-specific health information, (3) plain language, (4) semantic mapping of patient-level language to medical concepts, and (5) embedded editing and error-checking strategies to ensure maximal accuracy of patients' input.

3. Create an Architecture for the Display and Capture of Medication Data for Asthma

Computer interviews to collect historical data from patients are not novel; multiple versions of such technology have been engineered over the last four decades. However, no systems exist that collect medication histories during real-time clinical care. Building a medication history requires iterative questions that use previous answers to arrive at a detailed understanding of a patient's current medications. Developers targeting this knowledge domain must decide how to navigate an unmapped information space. A display of all asthma medications in alphabetical order would require that a patient

be able to scroll down on a page, recognize medications by their name alone, and make multiple selections off the main list to generate a complete list. These tasks may exceed the constraints identified in design goals 1 and 2 because of visual density, cognitive burden, and recall of medication-specific details using attributes other than name alone.

The interface and architectural requirements to solve this data capture problem include: (1) screen display that matches patients' mental model, (2) concurrent display of multiple attributes of medications, (3) a "one question per screen" approach to limit patients' task load.

4. Implement a Rules-based Approach to Link Parent-derived Data to "Best Practice" Guideline Recommendations in Pediatric Asthma

Current best practice of pediatric asthma care requires knowledge of a patient's chronic symptom severity and current medications.⁵ Parents are viewed as the primary resource for both of these data streams. Furthermore, parental report of current behaviors regarding devices for medication delivery and self-efficacy provide "actionable" data for education around best practices to support improved health.

Two primary goals were established to map parental report to existing standards of care for pediatric asthma: (1) link the report of chronic symptoms to guidelines on what constitutes chronic disease severity and (2) link the report of current medications to rules governing implementation of controllers (inhaled corticosteroid medications recommended as first-line therapy to treat the inflammatory component of asthma).

5. Create Output that Encourages "Activated and Informed" Patients and "Prepared and Proactive" Providers

We postulate that the benefit of improved front-end data capture and targeted messaging of patient-specific information includes greater collaboration between patients and providers during ED-based care.⁶ The deliverables to support this technology-driven collaboration include: (1) real-time multimedia output that provides feedback and alerts to parents in the form of brief, personalized, and focused health messages and (2) production of a child-specific action plan for use by responsible physicians and nurses that displays parent-acquired data in the context of appropriate steps for guideline-level care.

System Description

We created the asthma kiosk through a series of design, prototyping, and usability exercises over the course of 2002 through 2003. The system is described in terms of its physical attributes, information architecture, and specific interface features that address the previously mentioned design challenges. This project was approved by the Committee on Clinical Investigation of Children's Hospital Boston (Protocol 02-05-056).

Physical Structure

The system is deployed on a mobile kiosk structure purchased from SeePoint, LLC (Redondo Beach, CA). It includes the All in One self-contained terminal (15" Active Matrix LCD panel and touch screen [Resistive Touch by ELO]) mounted on an Ergotron mobile cart (Ergotron, Inc., St. Paul, MN). Wireless access and 24-hour battery pack allow for independence from the physical constraints of network

or power cables. Vertical and horizontal movement of the Ergotron arm allows for use in sitting and standing positions. The asthma kiosk operates as a mobile workstation, and can travel with the parent-child dyad within the ED space, facilitating data capture for a sicker population of patients who may be moved quickly from triage into a treatment room.

Software and Operating System

Windows 2000 serves as the operating system for the kiosk. The interface was designed using Visual Basic Professional 6.0 (Microsoft Corporation, Redmond, WA) with Access (Microsoft Corporation) as the back-end database. Real-time audio support for the personalized health message directed at parents was implemented using AT&T Natural Voices 1.4 (Wizzard Software Corp., Pittsburgh, PA). The system is locally based behind the firewall of Children's Hospital Boston.

System Design and Flow

The overall design mimics the look and feel of a bank automatic teller machine (ATM). In general, the system presents the parent with one question and four tasks per screen: (1) read the question, (2) choose an answer, (3) review it for correctness, and (4) move forward to the next question. The color and shape palette supports ease of navigation through consistency, grouping to allow for visual proximity of related items, and high contrast text/background at 14-point fonts to support readability. Audio files to complement on-screen text can be turned on or off as needed on a screen-by-screen basis. The interface personalizes the navigation by using the child's name and gender-specific pronouns in the display of content. These patient identifiers are entered into the computer by an administrator as the parent is logged onto the system.

Five modules presented in series constitute the final product: Introduction, Symptom Report, Medication Report, Care Needs and Home Assessment, and Output. If a user logs out of the system prior to completion of all five modules, they will restart at the module that was previously left incomplete.

The **Introduction** module achieves four objectives: (1) identify the language choice of the user (English or Spanish), (2) identify if the user wants audio support to continue (default is audio—ON), (3) introduce user to attributes of generic screen display, and (4) anchor parents' response bias to a 4-week frame of reference for the report of chronic symptoms.

The **Symptom Report** module displays eight questions previously validated by Lara¹⁵ that target chronic asthma severity. Figure 1 presents a screen shot from this module. Each screen uses text located near the GO TO NEXT SCREEN button to remind users to edit their selection.

The Medication Report module uses a hierarchical approach to the capture of current medication data, organized by route of delivery. It can be summarized as a HOW, WHICH ONES, and WHAT FEATURES approach. Parents are first asked to select HOW their child takes medicine for asthma. Once the routes of delivery have been established, the system presents each route with its associated medications (WHICH ONES). Third, each medication within a given route is then presented to acquire data on form, dose, and frequency (WHAT FEATURES).

Display of medication names occurs in tandem with images of each medication to encourage accurate reporting. Specific presentation of images with text allows the user to better dis-



Figure 1. Screen shot from Symptom Report module.

tinguish among closely related items. For example, a patient might verbally report that they take the "orange" version of Flovent (fluticasone). However, the three forms of this medication (which vary five-fold in concentration) all have an orange canister that encloses the actual inhalers that range in color from orange to brown. Only with actual display of those variations can higher accuracy be expected to occur (Fig. 2).

Doses of inhaled medication are anchored with definitions of the words "puff" and "breath" (Fig. 3). These definitions were implemented after one-on-one verbal interviews with parents of children with asthma revealed multiple interpretations for a word such as "puff" in the context of asthma. Frequency data are solicited using either a closed-end question structure for the report of daily controller medications or a clock metaphor for rescue medications given with variable frequency (Fig. 4). The clock display embeds a parent-child architecture: when a parent selects a given hour on clock, a child window appears that asks the parent to enter the number of treatments given in that hour.

To support accurate reporting, a summary screen redisplay entered information specific to a medication for the parent



Figure 2. Screen shot from Medication Report module: form of medication.

The following question asks about Steve's current use of Albuterol inhaler.

Of the following, what dose of the medicine best matches what you currently use for Steve?

☐ 1 puff

☐ 2 puffs

☐ 3 puffs

☐ 4 puffs

☐ Not sure

What's a puff?
One puff equals one downward push on the inhaler to release medicine.

Look at the answer you chose.
If you are satisfied with your answer then press the GO TO NEXT SCREEN box.

GO TO NEXT SCREEN

Turn sound back on Stop

Figure 3. Screen shot from Medication Report module: dose of medication.

to review and edit before moving forward in the interview. This summary screen represents the most complex display that a parent must navigate in this interface. It combines three main tasks: (1) review the displayed details of a given medication, (2) decide if the displayed information is correct, (3) endorse the information as correct or choose a specific element to edit (Fig. 5).

The **Care Needs and Home Assessment** module presents (in series) a select group of closed-ended questions, the screen display of which mimics that of the symptom report module. These questions are derived from previously developed surveys targeting use and access to necessary health services, parents' self-efficacy, and the report of environmental risks in the home.^{16,17}

The Output module presents a health message to the parent organized in four sections: (1) about your child, (2) what your child needs, (3) how the doctors and nurses can help, (4) how you can help your child. Parent-directed output created by the system operationalizes the concept of "information therapy" that prescribes the right information to the right person

The following question asks about Steve's current use of Albuterol inhaler.

Think about the last 12 hours.
Please choose all of the times (hours) during which Steve received a dose of the medication.

Current Time: 2:16:45 PM

☐ 11 am ☐ 12 Noon ☐ 1 pm

☐ 10 am ☐ 2 pm

☐ 9 am ☐ 3 pm

☐ 8 am ☐ 4 pm

☐ 7 am ☐ 5 pm

☐ 6 am ☐ Not sure

Look at the answer you chose.
If you are satisfied with your answer then press the GO TO NEXT SCREEN box.

GO TO NEXT SCREEN

Turn sound back on Stop

Figure 4. Screen shot from Medication Report module: frequency of medication.

Please review the information you entered regarding Steve's use of Albuterol inhaler.

Please change any information that is not correct.
Once you decide the information is correct, please choose the button 'To the best of my knowledge, the information is correct.'

Brand Name: Albuterol Route: inhaler

Product Form: 90 mcg per puff Dose: 2 puffs Frequency: 2 times at 2 PM

No other forms available ☐ I want to change the dose ☐ I want to change the frequency

☐ To the best of my knowledge, the information is correct.

Look at the answer you chose.
If you are satisfied with your answer then press the GO TO NEXT SCREEN box.

GO TO NEXT SCREEN

Turn sound back on Stop

Figure 5. Screen shot from Medication Report module: summary and review.

at the right time.¹⁸ Message content is derived from guideline recommendations and implemented using plain language. Real-time audio output reads the text-based message to the parent in either English or Spanish. A printout of the same message is provided to the parent as well (Fig. 6).

A copy of the patient-specific action plan generated for use by the nurse and physician caring for the child can be printed for distribution as part of the active paper medical record (Fig. 7). The action plan is both a targeted summary and a "to do" list. It can serve as a template for ED providers to review important and clinically relevant data with the parent. As a part of the medical record, it can be a working document to identify what needed actions have been completed over time during ED care. Although generated as a paper document, an electronic "pop up" window can be implemented for health care sites at which all documentation of care is electronically completed.

Status Report

Three prototypes of the asthma kiosk were tested over eight months. In-depth, semistructured qualitative interviews were conducted one-on-one with parents of children with asthma at the beginning of the development process to review word choice regarding symptom description, medication use, and delivery devices to ensure that semantic content of the computer-based interview would match parents' mental models. Content that had not been validated previously in Spanish was subject to translation and retranslation to ensure accuracy. The final version of the system underwent formative evaluation in the pediatric ED setting of Children's Hospital Boston.

Formative evaluation of the asthma kiosk included multiple methods of data collection and analysis: (1) evaluation of parents' time to complete kiosk, (2) parents' completion of written questionnaire to elicit summary judgments of usability, (3) analysis of parents' kiosk entries and comparison to physicians' electronic medical records to describe the potential value of electronically entered data, (4) use of the NASA task load inventory to ascertain what domains of task load impacted parents' use of the system, (5) semistructured qualitative interviews with parents to explore their

Let's help Steve control his asthma!

*This information is based on what you told us about Steve.
It's designed just for you.
We want to make sure that Steve has a good breathing day every day!*

About Steve:

- Steve's symptoms of asthma over the last month were 'moderate'.
- Steve takes 0 medicine to help control asthma each day.

What extra help does Steve need:

- To control his asthma, Steve should take a new inhaled medicine each day.
- A peak flow monitor can help check on how Steve is doing with his asthma.
- Steve's symptoms of asthma may be helped by less exposure to smoke.

How the doctors and nurses can help:

- The doctor and nurse for Steve will talk with you about a new daily medicine to help control Steve's asthma.
- The doctor and nurse for Steve today will teach you the best ways to give medicine and check on Steve's asthma.
- A social worker is here in the emergency room to help families with issues such as coping with asthma and how best to keep your child healthy.

How YOU can help us to improve Steve's health:

- Talk to the doctor and nurse today. Show them this paper if you wish.
- Talk to the doctor and nurse about what daily medicines Steve needs to control his asthma.
- Talk to the doctor and nurse about using a peak flow meter to monitor Steve's symptoms of asthma.
- Ask for more information about how to keep Steve healthy at home.

Figure 6. Sample output intended for parent.

perceptions of the automated health message produced by the kiosk.

Subject Recruitment and Study Protocol

A bilingual research assistant approached parents of children with asthma between the ages of 1 year and 11 years of age who reported verbally that their child took at least one medication for asthma. Parents were recruited in the pediatric ED of an urban tertiary care Children's Hospital. A total of 66 parents from an eligible sample pool of 105 parents (62.8%) were recruited to test the system. One parent did not use the computer after enrollment. A system update performed midtrial induced an inadvertent, catastrophic data loss on 16 subjects, leaving 49 parents' kiosk entries available for analysis. Table 1 details the demographic characteristics of the 49 parents with complete data.

Parents independently used the asthma kiosk while in the ED, either at nursing triage or in a treatment room. Data entered onto the asthma kiosk was not shared with ED physicians and nurses during this phase of evaluation. All parents completed a written questionnaire that included items on demographics, self-efficacy regarding asthma care, previous technology experience, and judgments as to the usefulness and ease of use of the asthma kiosk.

Time to Completion of Kiosk

Forty-six of 49 parents (93.9%) were able to complete the kiosk interview during their ED visit. Mean time for completion was 11.8 minutes with an SD of 5.2 minutes. The range of time to completion was 4.7 minutes up to 25.9 minutes. Time was recorded beginning with the parents viewing the first introductory screen and ending with the parent completing the last question screen on the kiosk. This temporal data may overestimate the actual time on task spent by the parent as the total time could include periods wherein the parent may have ignored the computer to attend to other tasks.

The number of medications reported ranged from 1 to 5 with a median and mode of 2. Total time using the kiosk was independent of number of medications reported (analysis of variance [ANOVA] test using 4 DF, F value of 0.08, $p = 0.98$).

Parents' Summary Evaluation of the Kiosk

The 65 parents who used the kiosk system to enter information about their child were asked to endorse or reject several value statements specific to the technology. Of the 65 parents, 62 (95.3%) agreed that the entering data on the kiosk "was a good use of their time." Nearly all subjects, 61 of 65 parents (93.8%), agreed that entering data on the kiosk "was a good

Patient name	Steve		
Current age	14 years		
Dov	1/26/2004		

Idealized asthma care
Parents told us what they know. Now let's act on their data and help!

Current symptoms and medications and recommended actions

1) Chronic severity for asthma: mild persistent

2) Data that supports this severity:

symptom	4 week frequency
cough	Some days
wheezing	A few days
shortness of breath	Some days
night time awakening	A few days

3) Current controller medications:
None

4) Recommendations for Steve, age 14 y:

· Prescribe flovent inhaler in 110 mcg form	completed Y/N _____
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Current parent-child needs and recommended actions

1) In support of best medication practice

Prescribe peak flow meter and teach proper use	completed Y/N _____
How to give medication using inhaler	completed Y/N _____

2) In support of environmental risk reduction

Eliminating smoke exposure*	completed Y/N _____
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3) In support of better access to care

* Social work can assist with evaluation and action on the identified needs.

Figure 7. Sample output intended for clinician.

use of their knowledge." Fifty-seven of 65 parents (87.7%) agreed that a parent could enter information using the kiosk "as well as a doctor or nurse could."

Parents were asked to compare their experience with the asthma kiosk to two other activities: (1) using a bank ATM and (2) writing down information on a piece of paper. Each question allowed for responses across a 5-point Likert scale from "much harder" to "much easier." Forty-four of 61 parents (72.1%) rated the asthma kiosk as easier/much easier to use compared with a bank ATM. Only 4 of 61 (6.6%) parents reported the asthma kiosk as harder to use than a bank ATM. Fifty-six of 63 parents (88.0%) rated using the asthma kiosk as easier/much easier than writing down the same information. Only two parents of the 63 (3.3%) rated using the asthma kiosk as more difficult than the act of writing.

Task Load Assessment

A consecutive series of 12 parents from the study sample completed the NASA Task Load Index. The NASA Task Load Index informs users' experience across five relevant fac-

tors: (1) mental demand, (2) physical demand, (3) time demand, (4) effort, and (5) frustration. A factor's weight is determined by responses to pairwise comparisons asking which one was more important during the subject's experience with the technology. Numerical ratings for each factor are generated through a visual analog scale anchored by bipolar descriptors (high/low). An overall workload score per subject was created by multiplying each numerical rating by the weight given to that factor by that subject and then dividing the total by the sum of the weights. Weights for the factors comprising task load were summarized across all subjects to determine those factors that affected users the most.

The five factors in rank order of importance were (crude summary score in parentheses): 1. mental demand (37), 2. effort (31), 3. time demand (28), 4. physical demand (18), and 5. frustration (6). Overall workload demonstrated a wide range of perceived burden (summary scores ranged from 4.5 to 90.1 [mean, 51; SD, 24.2]). The two parents who reported the highest task load burden had both used an

Table 1 ■ Subjects' Demographic Characteristics and Technology Background

Variable	Frequency	Percent
Highest level of education		
Did not finish high school	08	17
High school graduate/GED	11	23
Some college	10	20
College graduate	11	23
Post college degree	08	17
Subtotal*	48	100
Racial group		
Caucasian	12	26
Black	25	53
Asian/Pacific islander	03	06
More than one	05	11
Do not wish to answer	02	04
Subtotal*	47	100
Self-designation as Latino/a		
Yes	06	13
No	41	85
Do not wish to answer	01	02
Subtotal*	48	100
Use of ATM in last month		
Yes	40	82
No	09	18
Subtotal	49	100
Comfort with use of ATM		
Very uncomfortable	03	06
Uncomfortable	00	00
Neutral	01	02
Comfortable	05	10
Very comfortable	39	81
Subtotal*	48	100
Use of computer on daily basis		
Yes	30	61
No	19	39
Subtotal	49	100

*Subtotal does not equal 49 due to missing data.

ATM in the last month and reported being "very comfortable" with using an ATM.

System's Ability to Collect and Analyze Parents' Data in Context of Guidelines

Figure 8 outlines how parents' responses regarding children's chronic disease severity mapped to the standard terminology used in the National Asthma Education and Prevention Program (NAEPP) guidelines.⁵ We accounted for potential uncertainty in parents' report within the rule-based schema. The summary equation that produces a severity rank assigns a higher weight to nighttime symptoms given the importance that the NAEPP guidelines place on this topic. We conservatively interpreted the response categories of "few" and "some" by assuming that "few" indicated a frequency less than 2, and that "some" indicated a frequency greater than 2. We examined data entered by the 46 parents who completed the kiosk tasks to determine the system's ability to produce meaningful and "actionable" output. The asthma kiosk was able to generate a disease severity classification for 45 of 46 children (97.8%). The parents' report of current controller medications was compared with the classification assigned to their children by the system's rules. We considered med-

ications to be controllers if they matched a specific medication defined as such within the NAEPP guidelines. Twelve of 46 children (26.1%) were noted to have a disease classification of mild persistent disease or higher but did not currently take a controller medication as reported by the parent. By guideline criteria, this represents a population of children whose care requires action, a "step-up" to better control the disease.

The electronic medical records for the study cohort were abstracted and evaluated for the presence of documentation regarding chronic severity. Forty-three of 46 records were available for review. Only 2 of 43 records (4.6%) documented the level of chronic severity. Of the 12 patients identified by the asthma kiosk to be in need of a "step-up" in chronic control, only 1 of 12 medical records (8.3%) noted the degree of chronic severity. Documentation for this one subject noted a chronic severity of "mild intermittent asthma," which contrasts with the kiosk-endorsed chronic severity of moderate persistent disease.

The existence and use of a written asthma plan has demonstrated a protective effect for asthma children for the outcome of hospital admission.¹⁹ The **Care Needs and Home Assessment** module for the asthma kiosk included questions specific to this issue. Eighteen of 46 parents (39.1%) stated that they had not received a written asthma plan from the primary care doctor. Of the 27 parents who reported having such a plan in the past, only 16 (34.8% of the total sample of 46 parents) reported having a current copy.

Peak flow meters are recommended for adjunctive monitoring of obstructive patterns of respiration for children older than 7 years with persistent asthma symptoms.⁵ The **Care Needs and Home Assessment** module queried parents on whether they had a peak flow meter at home for use in disease monitoring. Twenty-one children older than 7 years were part of the study cohort. Eleven of 21 parents (52.4%) reported the absence of this device despite their child experiencing persistent symptoms of asthma.

Modifiable environmental triggers for asthma include tobacco smoke, dust mites, pet dander, and mold. The **Care Needs and Home Assessment** module asked parents about these triggers and the potential applicability to their home environments. Of the 46 parents who completed the kiosk, 22 of 46 (47.8%) reported at least one modifiable environmental trigger that could be a target for educational interventions. Physician awareness of environmental triggers was only documented in 3 of 22 charts (13.6%) for patients in whom the issue was a present-tense issue for disease management.

Parents' Comprehension and Reactions to Output Messages Created by the Kiosk

A consecutive series of 14 parents within the study sample completed a semistructured qualitative interview with a bilingual research assistant immediately after their completion of the kiosk. This interview elicited parents' perceptions of the content within the automated health message. The parent was first asked to review the paper output and then momentarily set the paper aside. The parent then was asked to share their overall understanding—"Tell me what you think the message is." Subsequently, the parent was invited to pick up the paper and use it to respond to three other

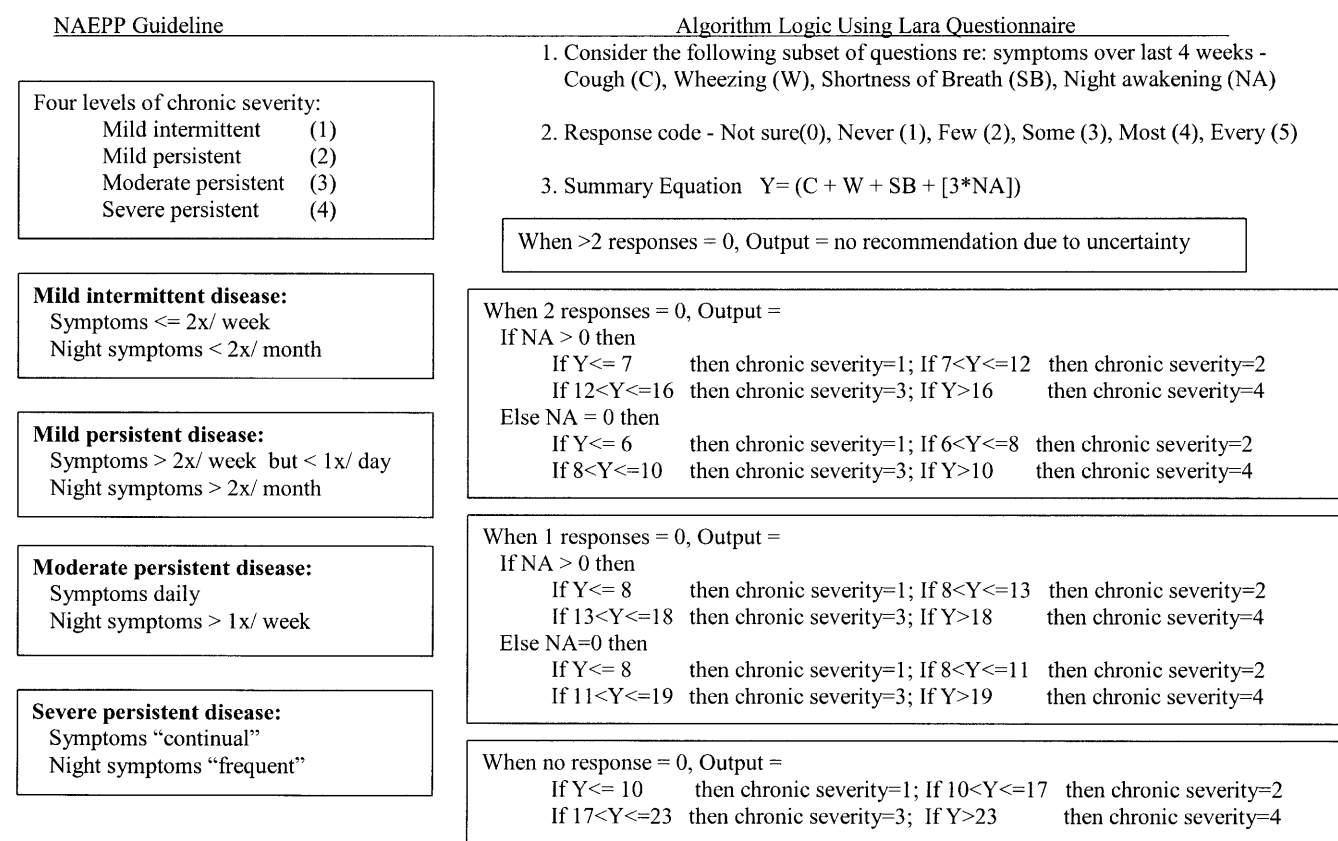


Figure 8. Summary of how parents' report of symptoms maps to terminology of NAEPP guideline.

questions: (1) What topics within the message did the parent perceive as important? (2) Were any words or sentences within the message confusing? (3) Did the parent disagree with any aspect of the message?

Parents' summary perceptions endorsed the system's overall goal of sharing a positive, action-oriented message. Ten of 14 parents reported that the message encouraged action, "how to" do something about their child's disease. Three of 14 parents focused on medication-specific aspects of the message. Eight of 14 parents noted topics of control and/or prevention as part of what they perceived the "take home" message to be. No parent reported difficulty with words or sentences included as part of the message. One parent voiced disagreement with the tailored output for her child, taking issue with the message that her child was not on any controller medications. As this parent reported albuterol, a rescue B2 agonist drug, as the only medication, the output message was correct but perceived as wrong by the parent who thought that albuterol was intended to control asthma. This case highlights a "teachable moment" that arises from the collaborative technology-based approach, as this parent's review of output exposed a misperception in how a medication actually works.

Discussion

The asthma kiosk is a novel patient-centered technology that links patients' raw knowledge to medical constructs and existing guideline algorithms, thereby allowing the parent to

drive the development of guideline-specific recommendations for care. The system meets seven of eight criteria espoused by Corb et al.²⁰ for the implementation of clinical practice guidelines that are specific to a given patient. The asthma kiosk opens a communication channel between patients and providers wherein patients themselves can lead the process of quality improvement.²¹

The physical mechanics of the asthma kiosk successfully adjust to constraints of parents caring for a sick child and the ED environment itself. Nearly all parents were able to complete all modules on the kiosk within the time frame of their visit in the ED. The time demand imposed on parents averaged 11 minutes, which allows parents to complete data entry during iterative periods of waiting. Parents recognize the mental effort and time cost attributable to use of the kiosk but nonetheless overwhelmingly endorsed the value of their interaction with the system.

The neutrality of the asthma kiosk was a primary concern: would this technology limit or disenfranchise any particular group of parents? Our study cohort included individuals with lower educational achievement (19% with a high school education or less) as well as important minority groups (17% Latino, 25% black) who have been noted to bear a disproportionate share of the asthma burden.^{22,23} Parents who report low self-efficacy on asthma knowledge or treatment strategies might be considered "at risk" to experience more burden in using the asthma kiosk. We did not find this to be the case. To test neutrality, we examined parents' response to the item "Compared to a bank ATM, is the kiosk harder or easier to

use?" No specific technology factor (ATM use in last month, daily use of a computer, comfort with using an ATM) or demographic characteristic (educational level, racial group, or self-designation as Latino) predicted the perception of difficulty.

The asthma kiosk represents a novel patient-derived electronic solution to gathering medication history. We created a system flow and interface design that support parental report on all asthma-specific medications across multiple levels of detail. The hierarchical approach allows for the a priori large number of medications to be parsed into smaller lists more amenable to dual text/image display on a screen with limited real estate.

The value attributed to the asthma kiosk can be measured in the type and quantity of "actionable" items that can be generated from compiling and analyzing parents' raw data. More than one quarter of patients within the study sample had a level of disease severity that mandates controller therapy but they did not report a controller as a current medication at the time of the ED visit. ED physician awareness of chronic disease severity was notably absent from almost all documentation. Further, important resources such as a written asthma plan to guide the parents in treating asthma on an outpatient basis were absent for more than 50% of cases. Such a plan is considered protective against frequent hospital admission and an important marker of the quality of primary care.¹⁹ Both the medication-disease severity mismatch and the provision of a written asthma plan represent specific deficits that have a clear solution made visible through parents' use of the asthma kiosk.

The visible output of the asthma kiosk includes messages directed at the parent to encourage them to be "activated and informed" in accordance with Wagner's theory of idealized collaborative care.⁶ The interviews conducted with parents who used the system highlighted parents' successful grasp of the action-oriented aspects of the health message and their approval of its personal relevance to their child and family. We did not study the asthma kiosk's effects on actual care delivered during this preliminary stage of development; therefore, we cannot offer proof that the system improves care based on this formative evaluation. The impact of the kiosk on ED providers' actions and on parents' perceptions of ED asthma care will be tested in a clinical trial in 2004.

The asthma kiosk enables collaboration between parents and providers by providing "just in time" decision support tailored to a given child's history as reported by the parent. This formative evaluation does not prove that the kiosk creates collaboration but does offer strong evidence for its ability to support collaboration by providing patient-derived data in a structured form to ED providers that includes "actionable" content that is not currently captured during routine ED care.

Parents of children with asthma, and patients in general, already provide historical data through the verbal exchange of information as part of routine care. The asthma kiosk functions as a concurrent communication channel through which parents can link their raw knowledge to the process of clinical care. Parental input can supply the process of ED-based evaluation with structured and more complete information to reduce variability in data capture and performance at the

system level.²⁴ The asthma kiosk holds promise for patient empowerment and provider empowerment through a two-step process: (1) the front-end, parent-driven, electronic capture of relevant medical history to populate algorithms based on accepted guidelines and (2) dual dissemination of an action plan to the parent and to clinical providers to encourage each participant to act collaboratively towards improving health.

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